

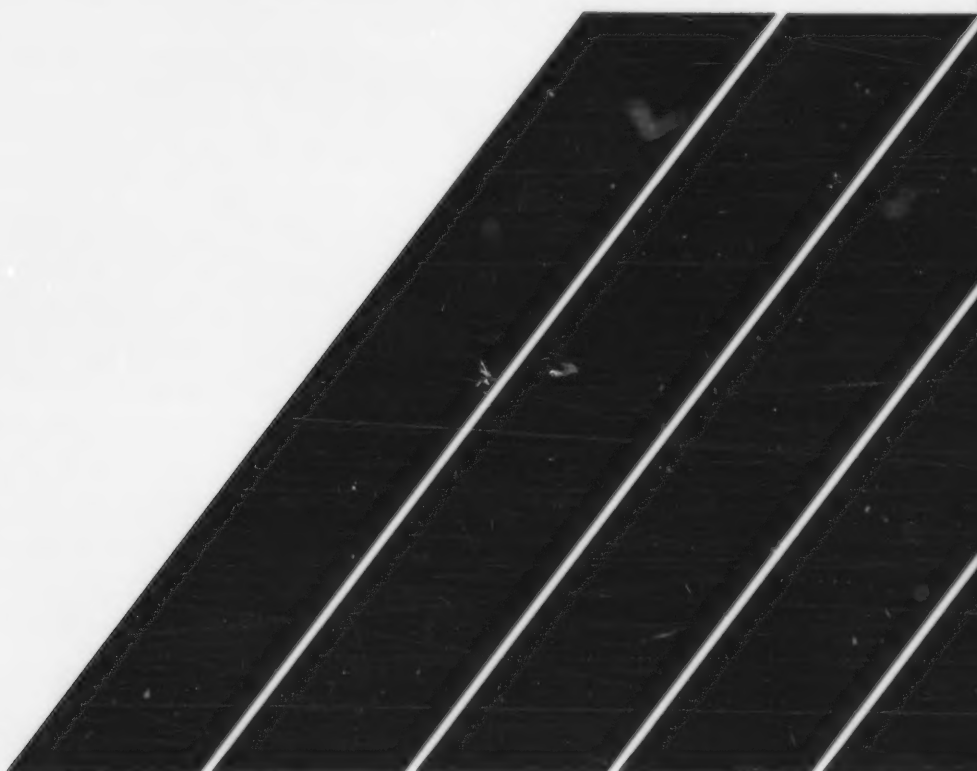
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**MINE DESIGNER - AN AUTOMATED GRAPHICAL DATA
GENERATION PROGRAM INTEGRATING NUMERICAL
MODELLING WITH THE MINE DESIGN PROCESS
(SUN Version 1.0)**

MRL 91-31(TR)

July 1991

by

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l'énergie (CANMET).

**BEAP3D - BOUNDARY ELEMENT APPLICATION PACKAGE
FOR THREE DIMENSIONAL ANALYSIS
OF MINE STRUCTURES
(Sun version 1.0)**

The BEAP3D system consists of three separate modules, namely: MINE DESIGNER, BEAP and VIEWBEAP. Three user manuals, published separately, are provided. The three user manuals are listed below:

- 1- MINE DESIGNER** - An Automated Graphical Data Generation Program Integrating Numerical Modelling with the Mine Design Process.
- 2- BEAP** - Boundary Element Analysis Program for Three Dimensional Analysis of Mine Structures.
- 3- VIEWBEAP** - An Advanced 3-D Graphical Representation Program for BEAP.

Hardware Requirements:

Minimum Configuration: a Sun Sparcstation computer with colour graphics monitor, 200 megabytes of hard disk, 8 megabytes of RAM.

Suggested Configuration: a Sun Sparcstation computer with colour graphics monitor, 400 megabytes of hard disk, 16 megabytes of RAM.

Software Requirements: SunOS 4.1.1 Operating System, or SunOS 4.1 Operating System plus OpenWindows Version 2.

Reference to this manual should be quoted as follows: "MINE DESIGNER - An Advanced Graphical Data Generation Program Integrating Numerical Modelling with the Mine Design Process (Sun Version 1.0), Divisional Report MRL 91-31(TR)"

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1. INTRODUCTION

MINE DESIGNER (MD) is a data generation program for use with the three-dimensional boundary element analysis program BEAP. MD allows the user to graphically define a mining problem using advanced Computer Aided Design techniques from various stages along the mine design process.

The major aspects of mine design included in MD are: drill hole visualization, ore body definition and visualization, piping (shafts, drifts and raises) definition and visualization, and stope definition and visualization.

One of the major capabilities of MD that can be applied directly to the BEAP3D system is stope definition and visualization. All other data is maintained for the benefit of the user, to aid in the difficult task of defining a representation of a complex 3-Dimensional problem and to integrate numerical modelling with the mine design process. The program can also be used as a visualization tool of an overall mine, however, this is not the primary function of MD.

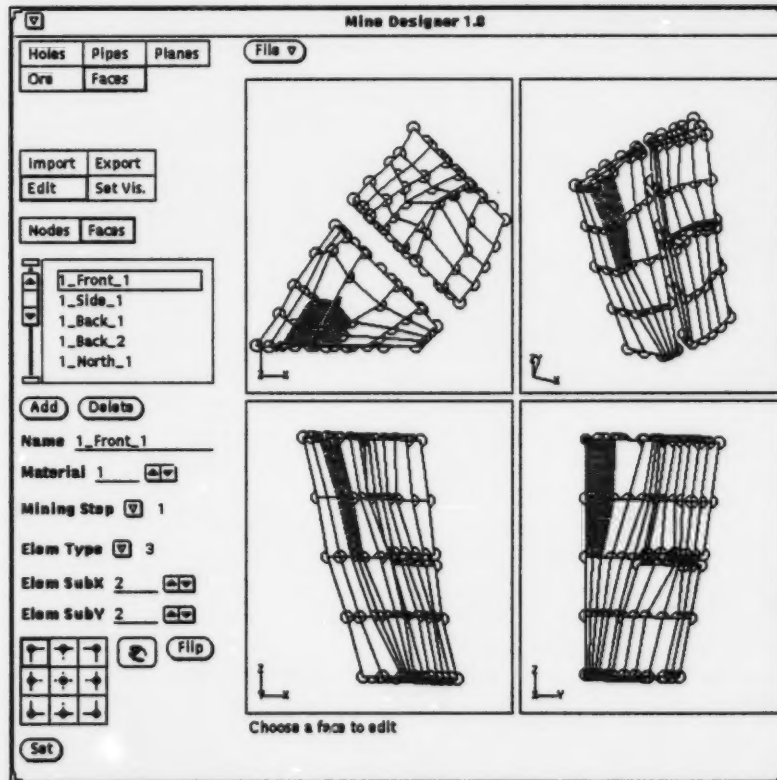


Figure 1 - Mine Designer main window

The first window which shows up on the screen is referred to as the Mine Designer Main window. The main window, with one of the five functions selected and shown in the upper left corner of the window is illustrated in Figure 1.

1.1 The BEAP3D Design Cycle

MD is an integral part of the BEAP3D Design Cycle as it is the starting point. The BEAP3D system has been designed to be as user-friendly and as automated as possible, however, the user is ultimately the key to the accuracy and performance of the system. Most of the key decisions regarding the integrity and complexity of the problem are defined in the MD.

The BEAP3D system is intended to be used as a cycle, not a one-shot process. Mine design requires optimization and evolves with decision making. MD is intended to be a true editing tool to allow quick turnaround when trying different situations.

1.2 Program Layout

MD is designed to be as user-friendly as possible without limiting the functionality of the program. There are no complicated commands or keystrokes to remember. The program is designed to minimize the amount of steps required to complete a task while being as consistent and simple to use as possible.

Several "simple words" were selected and used with the dialogue-driven menu system. Therefore, it is important for the users to understand the definitions of these MD terminologies and their main functions. These terminologies associated with the five major functions as discussed are briefly described below:

- Holes This refers to drill holes. It imports and displays the drill hole data of a mine.
- Ore It refers to the orebody. 3-D orebodies can be constructed, edited and displayed providing an excellent means for the visualization of orebodies. This is essential for the integration of numerical modelling with the mine design process.
- Planes A plane is a general purpose rectangular surface defined by its width, height and origin (center point). Planes can be oriented in different ways to provide useful 3-D construction aids for laying out pillars and stopes in 3-D and/or defining cross-sectional views.
- Pipes This refers to piping. In other words, it deals with drifts, ramps, ore-passes, raises and shafts, etc. They can be easily created, edited and displayed.
- Faces It refers to stope faces. This function is closely related to the generation of 3-D BE models. It graphically creates and edits mining stopes and pillars, and generates all of the geometric input data required by the BEAP program.

MD requires the use of a mouse for most of the operations of the program. Graphical User Interfaces are always heavily reliant on digitizers such as a mouse and MD is no exception. Users are expected to be familiar with the operation of a mouse.

2. GETTING STARTED

2.1 Program Execution

MD is an X windows application. The current implementation of MD requires SUN OpenWindows 2.0. OpenWindows must be loaded prior to MD. For the experienced user, it is possible to run MD on a Sun client and viewed from an X terminal. MD may also be viewed on a monochrome terminal, however, the results may be somewhat unappealing.

MD can be started from a command shell by simply executing "minedes", assuming that MD is located in the current directory or on the executable search path.

MD may also be executed from the OpenWindows File Manager. For more information, please refer to the documentation provided with OpenWindows.

2.2 Screen Layout

MD uses only one main window (sometimes called a Frame). This is intended to minimize the amount of window maintenance by the user. The main window contains three important areas: the dialogue menu, views and view response area. Figure 1 illustrates these areas.

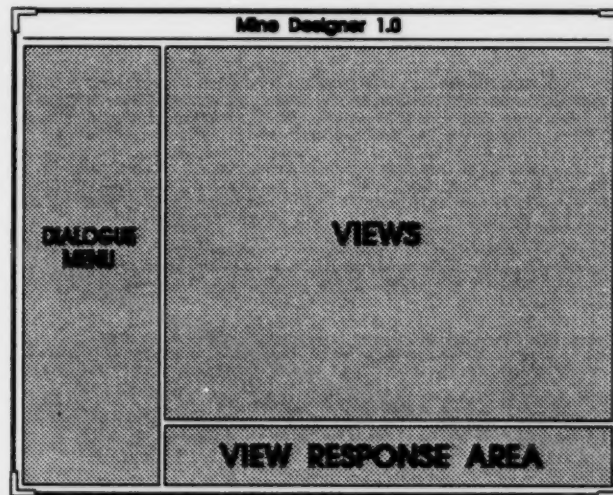


Figure 2 - the main window layout

The DIALOGUE MENU

The dialogue menu is more than just a means of accessing commands, it also controls the state of MD. The menu is described in greater detail later in this section.

The VIEWS

The views allow the user to continually view a representation of the current model as well as provide a graphical means of data selection and modification. It is imperative that the user be proficient in the use of the views as they provide most of the functionality and versatility of MD.

The VIEW RESPONSE AREA

From time to time, there will be a need to respond to questions from the program that cannot be accommodated by the dialogue menu. The view response area will reflect these questions.

2.3 Opening and Saving Sessions

All of the data regarding the makeup of a model are stored together in one session file. These files are used only by MD and cannot be accessed by any other program.

Creating a new session

Select the "*File, New*" menu item to begin a new session. All data currently contained in MD is lost and the views are reset to a suitable position to start the model definition.

Opening a Session

Select the "*File, Open...*" menu item to open an existing session. The user is then prompted for the name of the session file to be loaded. The views are then adjusted so that the entire model is visible. All data previously contained in MD is lost.

Saving a Session

Select the "*File, Save...*" menu item to save the current session. The user is then prompted for the name of the session file to be written to. The previous contents if any of the file are overwritten.

2.4 Using the Dialogue Menu

The dialogue menu has several purposes: it provides the direction or state of the program while at the same time providing most of the input fields associated with the model. The dialogue menu is arranged in what is often called a tree structure. Figure 3 illustrates the tree diagram for MD.

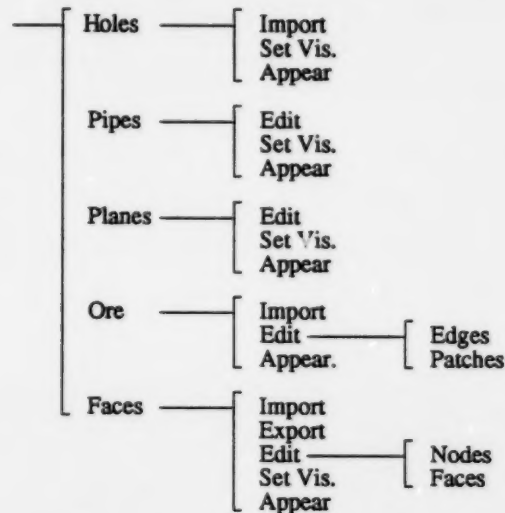


Figure 3 - The menu structure of MD

Only one part of the menu is visible at a time. For example, if the edges (i.e. boundaries) of an ore body are being edited, the visible part of the menu would be identified as "*Ore, Edit, Edges*". Figure 4 shows the dialogue menu area for this example.

Holes	Pipes	Planes
Ore	Faces	

Import	Edit
Set Vis.	Appear.

Edges	Patches
-------	---------

☐

Figure 4 - Example of the Dialogue Menu for "*Ore, Edit, Edges*".

To branch to a different part of the menu, simply click on the desired label. For example, to change from "*Ore, Edit, Edges*" to "*Ore, Import*", simply press the "*Import*" label.

All sub-branches are left as they were during menu changes. For example, if the "Planes" label was pressed and then the "Ore" label, the menu strip would then return the menu to "Ore, Edit, Edges".

2.5 Importing and Exporting

In various sections of MD, importing and exporting capabilities are provided. Drill hole data, ore body outlines and stope face data may be imported while only stope face data can be exported. The data file formats can be found in section 9.1. A detailed description of the importing and exporting options can be found in the sections of the manual pertaining to the data type being imported or exported.

2.6 Object Appearance

It is often necessary to change the appearance of the mine data to help clarify the model. For example, it is convenient to make the ore body transparent when considering the position of the stope faces relative to the ore body so that the stopes "show through". The different appearances also affect the amount of time necessary to redraw a view.

To change the appearance of a data type, simply select the applicable "Appear." menu item and select the required appearance choice.

For all data types except drill holes, the available choices for appearance consist of: shaded, solid, transparent and wire frame. Drill hole appearance is described in detail in section 4.2. The following table describes the look and graphics speed for display of the different choices.

Appearance	Drawn as	Speed
"Shaded"	green shaded faces as if an imaginary light source was present with hidden surface removal	Medium
"Solid"	solid coloured faces with hidden surface removal	Medium
"Transparent"	grey transparent faces with objects behind partially showing through	Slow
"Wire frame"	black lines	Fast

2.7 Object Visibility

It is often necessary to temporarily hide pieces of the model to speed up the regeneration of the graphics or remove obstructions. All data types can be temporarily hidden from the graphics.

To activate the visibility menu for a data type select the applicable "Set Vis." menu item. Four buttons become available: "All Visible", "All Invisible", "Selected Visible" and "Selected Invisible". Any objects that are to be hidden will be visible as grey transparent objects, while all other objects will appear normal. When the "Set Vis." sub menu is not displayed the hidden objects will disappear.

Note: Some care must be taken to ensure that the appearance (as described above) of the data type is not transparent because it will be impossible to distinguish between the hidden and visible objects.

- *To make all objects of the data type visible or invisible:*
 - Press the "All Visible" or "All Invisible" button.
- *To make one objects of the data type visible or invisible:*
 - Click on the object in any of the views, then press the "Selected Visible" or "Selected Invisible" button.
- *To make a region of the data type visible or invisible:*
 - Click and Drag out a box around the objects to be affected and then press the "Selected Visible" or "Selected Invisible" button.

3. USING VIEWS

3.1 Views

The user can view the model through one or more views. Each view is a window with an axis and an optional grid and it can be oriented independently from any other views. The size and shape of a view depends on the size of the main window and the current view layout.

Although each view has an independent orientation, all views work together to provide a consistent means of graphical input.

3.1.1 Coordinate System

The coordinate system for MD adheres to the right hand rule with the z-axis representing elevation in the vertical direction. The axis in the bottom left corner of each view always reflects the orientation of the view. Figure 5 illustrates the coordinate system.

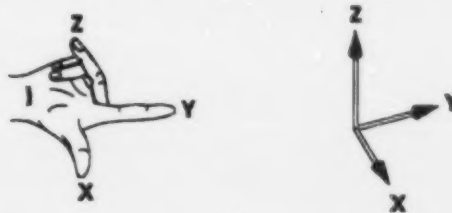


Figure 5 - the coordinate system

3.1.2 Eye Position, Rotation and Extents

The orientation of a view is defined by three properties: the eye position, current rotations and extents of the view.

- **Eye Position**

The eye position defines a 3-dimensional point corresponding to the centre of the view.

- **Rotations**

There are two rotations available to the user: the bearing and the dip. Limiting the user to only two rotations guarantees that the model will be upright and easily manipulated.

- **Extents**

The extents of a view define the size of the model in the view. The horizontal and vertical extents are always adjusted to keep the model's aspect ratio correct.

The third and more subtle extent is the thickness of the view. The thickness determines how much of the scene is visible in front and back of the eye position. A thickness of zero produces a cross section of the model.

Figure 6 illustrates the orientation properties of a view.

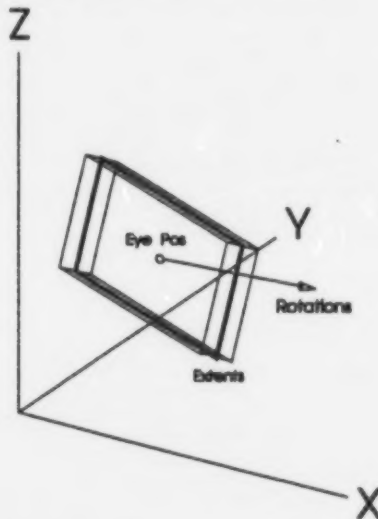


Figure 6 - View orientation properties

3.1.3 View Layout

The user is given a choice as to the layout of the views. The available configurations are illustrated below. Note the numbering of the views; when changing layouts, the views move to their respective places. The last arrangement (Maximized Window) is not really a layout but is included to show all possible configurations.



Quad Layout

(Default)



3 and 1 Layout



1 and 1 Layout



Maximized Window

3.2 View Controls

There are two different types of view controls: **menu controls** and **keyboard controls**. The menu controls typically include the more powerful and lesser used functions while the keyboard controls include the more interactive functions.

3.2.1 Menu Controls

Each view has a popup menu associated with it. This menu can be accessed by pressing the right mouse button while the mouse pointer is within the view. Figure 7 illustrates the menu.

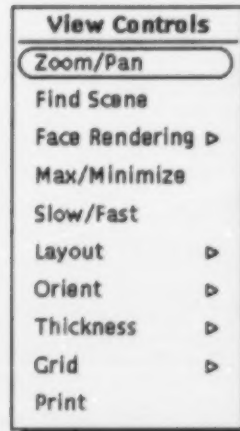


Figure 7 - The view control menu.

"Zoom/Pan"

This control is used to move the eye position and the horizontal and vertical extents. After selecting "Zoom/Pan" the user is expected to perform one of the following operations:

- *to Zoom In:* click and drag out a box with the left mouse button around the area of the view to zoom into.
- *to Zoom Out:* click and drag out a box with the right mouse button specifying the size that the currently visible area will become.
- *to Pan:* click on a point in the view with either the right or left button that will become the centre of the view.
- *to Cancel:* click on the centre mouse button to cancel the operation.

"Find Scene"

This control is used to change all extents such that the entire model is visible.

"Max/Minimize"

This control is used either to make the current view full size or to return the views to the current layout.

"Slow/Fast"

This control is used to toggle between slow and fast rendering. Slow rendering produces proper hidden surface removal at the cost of speed. Fast rendering is most useful for interactive sessions at the cost of image accuracy.

"Layout"

This control is used to change the current layout. The available choices are: "quad", "3 and 1" or "1 and 1".

"Orient"

Use this control to move the eye position and change the rotations in an orderly way. There are several choices available:

- "to XY Plane" The user is prompted for the new eye position and the view is then rotated so as to properly view the X and Y axes.
- "to YZ Plane" The user is prompted for the new eye position and the view is then rotated so as to properly view the Y and Z axes.
- "to XZ Plane" The user is prompted for the new eye position and the view is then rotated so as to properly view the X and Z axes.
- "to 3 Points" The user is prompted for 3 points that define a plane. The eye position is set to the first point and the view is rotated to point into the plane.
- "to a plate" The user is prompted to click on any flat plate in any of the views. The eye position is then set to one of the corners of the plate and the view is rotated to point into the plate. Unwanted affects may occur if the selected plate is not flat.

"Thickness"

This control is used to change the thickness of the view. There are three choices available:

- "zero" Produce a cross-section of the model through the current eye position.
- "define..." The user is prompted for the required thickness producing a slice of the model centered at the current eye position.
- "infinite" Remove the effects of thickness.

"Grid"

This control is used to change the properties of the view's grid. There are three choices available:

- "off" Turn the grid off.
- "Auto" The view produces a grid with appropriate spacing and labels. This is the default.
- "define..." The user is prompted for the spacing of the grid. Labels are placed on the grid lines at appropriate locations.

Print

This control produces a PostScript File ".post.ps" that will produce an image similar to what is visible in the view.

3.2.2 Keyboard Controls

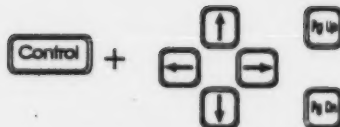
Several keyboard controls have been included to provide interactive movement and orientation. They are:



Rotate view by the rotation increment



Scale the rotation increment by 2 or $\frac{1}{2}$ respectively (Default 10°).



Move eye position relative to current orientation by the movement increment.

Note: Up and Down arrows move the eye position forward and backwards while the PgUp and PgDn keys move vertically.



Scale movement increment by 2 or $\frac{1}{2}$ respectively (Default 1 unit).

3.3 Coordinate Entry

Inputting the coordinates for 3-dimensional points is an integral part of MD. To keep the interface consistent, all coordinates are entered using this same procedure. During point entry, the view response area takes the following form:

X: 0.00	Y: 0.00	Z: 0.00	Mode: ☒ XYZ	Snap: ☒ None	SET	Cancel
Tape ☒	Dist 0.00	Set Tape				

Figure 8 - View response area during point entry

Keyboard entry

To enter the coordinates using the keyboard, simply change the values in the x, y and z fields of the view response area and press the "Set" button.

Mouse entry

During coordinate entry a  pointer symbol will appear in each view showing the current location. These symbols can be moved according to the current selection mode by simply clicking and dragging the mouse with the left mouse button in any of the views. The x, y, and z values in the view response area will automatically be updated. To accept the location, press the "Set" button or press the centre mouse button. The "Cancel" button is used to cancel the operation.

3.3.1 Point Selection Modes

The current selection mode can be changed using the "Mode" item in the view response area. The four available modes are:

- "XYZ" (Default) Simply move the pointer in any of the views. The pointer is always moved parallel to the view's orientation.
- "On pt" Click on any point or vertex in a view to move the pointer to that location.
- "Mid" Click on any line or plate edge to move the pointer to the midpoint of the segment.
- "Along" Click and drag the pointer along a line or plate edge.

3.3.2 Measuring Tape

A measuring tape feature is provided to measure the distance from the current location to a secondary location. A  pointer symbol appears in each view to indicate the secondary location. The "Tape" check box turns this feature on and off. The "Dist" field specifies the current distance. The "Set Tape" button copies the current location into the secondary location.

3.3.3 Snapping

The coordinates generated by moving the mouse may be cleaned up (removing insignificant figures) by changing the "Snap" value. The x, y and z values are rounded to the nearest increment of the "Snap" value. The snap choices are: 5, 2, 1, 0.5, 0.2, 0.1, 0.05, 0.02, 0.01. For example, the number 121.3484 would be rounded to 121.4 if the "Snap" value was 0.2.

4. DRILL HOLES

Drill holes are considered to be more or less drawing aids within MD. They can be imported and viewed to help define other mine elements such as ore body outlines. The representation of a drill hole is reasonably simple: a series of two-coloured lines with a text label at the starting point. The lines are colour coded red and black to indicate segments above and below a given grade.

4.1 Importing Drill Holes

Drill hole data is imported from text data files. The format for these files can be found in section 9.1.1. Drill hole data can be imported to replace or add to MDs existing data. The "Holes, Import" menu is shown below:

Holes	Pipes	Planes
Ore	Faces	

Import	Set Vis.	Appear.
--------	----------	---------

Filename _____

Waste cutoff _____

Waste length _____

Ore length _____

Add	Replace	Import
-----	---------	--------

Figure 9 - The "Holes, Import" Menu

A compression scheme is provided to enhance MD's performance and memory requirements. As a drawing aid, drill hole data points can be spread far apart in waste areas and more closely spaced in areas of interest (ore). To accommodate this scheme, three user defined values must be determined: the waste cutoff grade, the best length of waste segments, and the best length of ore segments. Knowing these values, MD will combine any segments that when combined will still be shorter than the best length for ore and waste areas. The grades for combined segments are calculated by a weighted average (i.e. $g_c = (g_1 \times l_1 + g_2 \times l_2) / (l_1 + l_2)$). Depending on the accuracy of the original file data, the results of the compression can dramatically affect the performance of MD.

4.2 Drill Hole Appearance

The Drill Hole Appearance menu provides a means of selecting the grade type and cutoff displayed in the colour-coding of the drill holes. The grade type is simply a value between 1 and 4. The cutoff defines which segments of the drill holes will be coloured red and which will be coloured black. The "Holes, Appear" menu is shown below:

Holes	Pipes	Planes
Ore	Faces	

Import	Set Vls.	Appear.
--------	----------	---------

Show Grade

1	2	3	4
---	---	---	---

Grade Cutoff _____

Figure 10 - The "Holes, Appear" menu

To change the appearance of the drill holes simply set the "Show Grade" and "Grade Cutoff" to the required values and press "Set". All segments having a grade of the selected type greater than the cutoff value will be drawn in red and all others in black.

5. ORE BODY DEFINITION

An ore body is represented by a collection of surface patches that define the transition from minable to unwanted ore. These surface patches are created by an automatic mesh generator built into MD. The mesh generator creates the surface by "sweeping" one or more sets of edges. The edges provided to the generator can be imported from text files or input directly. The edges can be edited and broken down into smaller edges.

A set of edges consists of one or more touching edges that can be connected end to end to construct one path. If the resulting start and end points touch, the set of edges is said to be closed.

There are effectively two different types of surface patches: caps and sides. A cap surface is constructed when only one closed set of edges is provided. Side surfaces are constructed when two sets of either open or closed edges are provided. Figure 11 illustrates the different types of patches.

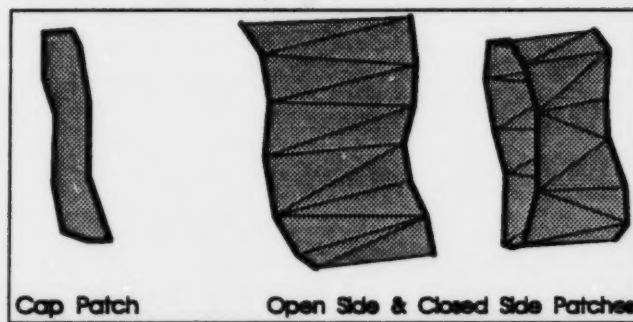


Figure 11 - The different types of Ore Body Patches

Cap patches are drawn as a solid polygon while side patches are made up of multiple triangles. When creating side patches, the mesh generator must match the points on one edge set with those of the other. The second set of edges is automatically reversed if the generator determines that the ordering of the points is in the opposite direction. The matching of the points can be customized by the user to handle special circumstances by introducing a shape coefficient that determines the preference of the generator between shape and point proximity. For example, figure 12 illustrates two different patches that can result from the same edge sets.



Figure 12 - Example of different shape coefficients

A more detailed description of ore body editing can be found in the following sections.

The mesh generator assumes that the shape of the edge sets for side patches will be *reasonably* similar in overall shape. If two edge sets produce a patch that is not acceptable, the patch may have to be broken down into smaller patches. This can be accomplished in several ways. One method would be to break the edge sets into more manageable pieces. Another method would be to introducing an intermediate edge set between the existing ones.

There are often severe cases of shape dissimilarity that require some ingenuity. An example is provided in section 10.1 to illustrate some of the considerations and planning that are required for modelling real ore bodies.

5.1 Importing Ore Body Cross-sections

Ore body edges can be digitized outside of MB and then imported. The file format can be found in section 9.1.2. To import an edge file, set the menu to "*Ore, Import*", enter the filename in the space provided and then press "Import". The edges in the file are added to the existing edges.

5.2 Editing Ore Bodies

The editing of ore body edges and patches is handled separately. The following sections describe each type of editing.

5.2.1 Ore body Edges

To begin edge editing, set the menu to "*Ore, Edit, Edges*". While in this menu, the edge currently being edited will be highlighted in red. Small circles will show the location of the points along the edge. To allow for mistakes, any changes to an edge are not recorded unless the "*Set*" button is pressed (except where noted). To ignore any changes simply select another edge or leave the "*Ore, Edit, Edges*" menu.

Holes	Pipes	Planes
Ore	Faces	

Import	Edit
Set Vis.	Appear.

Edges	Patches
-------	---------

☐ Closed

Figure 13 - The "*Ore, Edit, Edges*" menu

Procedures

- *to add a new edge*
 - press the "Add" button
 - enter all of the points on the edge
 - to finish, enter the same point as the last or Press the "Cancel" button.
- *to select an edge*
 - simply click anywhere on the edge in a view if it is not already selected
- *to delete an edge*
 - select the edge and then press the "Delete" Button
- *to select an edge point*
 - select the edge and then click in the circle highlighting the point (the highlighted circle will be filled)
- *to move an edge point*
 - select the edge point, click on the point again
 - enter the location of the new point
- *to insert an edge point*
 - select the edge and then click on the segment of the edge that is to be divided by the new point
 - enter the location of the new point
- *to append an edge point*
 - select the edge point at the end of the edge
 - press the "Extend" button
 - enter the location of the new point
- *to delete an edge point*
 - select the edge point and then press the "Delete Node" button
- *to break an edge*
 - select the edge point where the break is to occur and then press the "Break" button. If the edge was closed, it will be opened at that point. If the edge was open, the edge will be broken into two new edges. (Note: the current changes to the original edge will be recorded prior to the break).
- *to open or close an edge*
 - select the edge and then set the "Closed" checkbox to the required setting
- *to record edge changes*
 - press the "Set" button
- *to ignore an edge changes*
 - press the "Edges" menu item or select a different edge

5.2.2 Ore body Patches

To begin patch editing, set the menu to "Ore, Edit, Patches". While in this menu, the patch currently being edited will be highlighted in red and blue. Since a patch is generated from one or two sets of edges the red and blue highlighting differentiates between the two sets. To allow

for mistakes, any changes to a patch are not recorded until the "Set" button is pressed. To ignore any changes simply press the centre mouse button while in one of the views or leave the "Ore, Edit, Patches" menu.

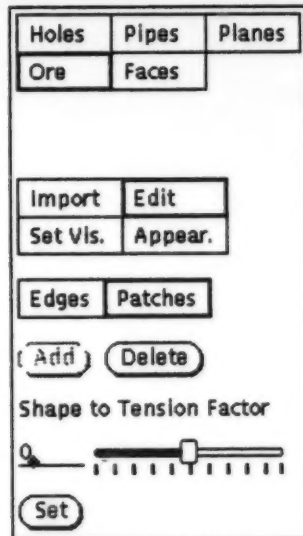


Figure 14 - The "Ore, Edit, Patches" menu

Procedures

- *to add/remove an edge from a patch*
 - click on the edge to cycle its status from "in edge set 1" (red), to "in edge set 2" (blue) to "in neither" (black). The colour of the edge changes to show its status.
- *to select a patch*
 - click on a part of the patch in any of the views
- *to add a new patch*
 - press the "Add" button
 - add the required edges
- *to delete a patch*
 - select the patch and then press the "Delete" button
- *to change the shape coefficient of a patch*
 - move the "Shape to Proximity" slider to the desired position
- *to record any changes to a patch*
 - press the "Set" button
- *to ignore any changes to a patch*
 - press the "Patches" menu item.

6. PLANES

A plane is a flat rectangular surface of a given width, height, centre point and orientation. The orientation of the plane is defined from one of six different methods describe later.

Planes are provided for several purposes. They are very useful as 3-dimensional construction aides for marking out such things as pillar locations in 3-D and cross-sectional views. They are useful as orientation tools because planes can be added for each mining level and then used to reorient views (see section 3.2.1 regarding "Orient", "to a plate").

6.1 Editing Planes

To begin plane editing, set the menu to "Planes, Edit". While in this menu, the plane currently being edited will be highlighted in red and the edit fields in the menu will show the current parameters defining the plane. To allow for mistakes, any changes to a plane are not recorded until the "Set" button is pressed. To ignore any changes simply select a different plane in one of the views or leave the "Planes, Edit" menu.

Holes	Pipes	Planes
Ore	Faces	

Edit	Set Vls.	Appear
------	----------	--------

Add

Delete

XY Plane	YZ Plane
XZ Plane	3 Points
Dir, Dip	Norm, Rot

Width 0.00

Height 0.00

Origin 0.00,0.00,0.00 

Set

Figure 15 - "Planes", "Edit" menu

All planes have "Width", "Height" and "Origin" (centre point) parameters. Three of the six orientation types have additional parameters. A detailed description of the six orientation types follows:

- "XY Plane" A plane oriented parallel to the X and Y axes.
- "YZ Plane" A plane oriented parallel to the Y and Z axes.

- **"XZ Plane"** A plane oriented parallel to the X and Z axes.
- **"3 Points"** A plane oriented by three points. Two additional fields define the other points: *"2nd Pt"* and *"3rd Pt"*.
- **"Dir, Dip"** A plane oriented by two angles. The *"Direction"* field specifies the z-rotation or bearing. The *"Dip"* field specifies the dip of the plane from the horizontal.
- **"Norm, Rot"** A plane oriented by a normal and a twisting rotation. The *"Normal"* field specifies a vector (X,Y,Z) defining the plane's normal. The *"Rotate"* field defines the twist of the plane.

Note: When orienting a view to a *"Norm, Rot"* plane, the *"Rotate"* field is ignored.

Procedures

- *to add a plane* - press the *"Add"* button. The edit fields are left as they were when the last plane was edited. This allows the user to duplicate planes and then change only the parameters that differ.
- *to select a plane* - click on the plane in one of the views. The plane will be highlighted in red.
- *to delete a plane* - select the plane and then press the *"Delete"* button.
- *to edit a plane* - select the plane and then change the fields that require editing.
- *to record changes* - press the *"Set"* button.
- *to ignore changes* - select another plane or press the *"Edit"* menu item.

7. PIPING DEFINITION

The name piping refers to the all drifts, shafts and raises, etc. MD includes the definition of piping to allow for better visualization of the model. MD's representation of piping is simple to insure that it is an easy tool.

A pipe is defined to be a series of points with varying width, height and rotation parameters. The representation of the pipe is generated by "sweeping" a rectangular cross-section along the centre line specified by the series of points. The size, shape and orientation of the cross-section varies along the centre line according to the parameters provided at each point.

A pipe can be created, edited, broken into smaller pipes and deleted. As with all other objects in MD, the appearance and visibility of pipes can also be changed.

7.1 Editing Piping

To begin pipe editing, set the menu to "*Pipes, Edit*". While in this menu, the pipe currently being edited will have its centre line highlighted in red. The points on the centre line will be drawn as empty red circles. The point on the centre line currently being edited will be highlighted with a solid red circle. The edit fields in the menu will indicate the parameters for that point. To allow for mistakes, any changes to a pipe are not recorded until the "*Set*" button is pressed. To ignore any changes simply select a different pipe in one of the views or leave the "*Pipes, Edit*" menu.

Procedures

- *to add a new pipe*
 - press the "*Add*" button
 - enter all of the points on the pipe
 - to finish, enter the same point as the last or press the "*Cancel*" button.
- *to select a pipe*
 - simply click anywhere on the pipe in a view if it is not already selected
- *to delete a pipe*
 - select the pipe and then press the "*Delete*" Button
- *to select a point*
 - select the pipe and then click in the circle highlighting the point (the highlighted circle will be filled)
- *to move a point*
 - select the centre line point and then click on the point again
 - enter the location of the new point
- *to change the parameters for a point*
 - select the centre line point.
 - change the required parameters
- *to insert a point*
 - select the pipe and then click on the segment of the centre line that is to be divided by the new point
 - enter the location of the new point

- *to append a point*
 - select the centre line point at the correct end of the pipe
 - press the *"Extend"* button
 - enter the location of the new point
- *to delete a point*
 - select the centre line point and then press the *"Delete Node"* button
- *to break a pipe*
 - select the centre line point where the break is to occur and then press the *"Break"* button. The edge will be broken into two new edges. (Note: the current changes to the original pipe will be recorded prior to the break).
- *to record pipe changes* - press the *"Set"* button
- *to ignore any changes* - press the *"Edit"* menu item or select a different pipe

8. STOPE FACE DEFINITION

Stopes are constructed from faces in MD. A face can be a triangle, a linear quadrilateral or a quadratic quadrilateral depending on the number of nodes that define it. The faces are subdivided into elements according to the properties of the face.

The user has full control over the definition of the stope faces. The user is responsible for defining all of the nodes (points) used by the faces and the construction of the faces. The additional nodes created by the subdivision of the faces are maintained by MD. The faces must be defined in a constant order. When a face is viewed from within the rock the nodes must be ordered in a clockwise direction. Faces ordered in the opposite direction will be painted solid grey while those ordered correctly will be coloured according to the defined "appearance" for stope faces.

Stope faces have several properties associated with them to describe their geometry and characteristics. These properties are:

"Name"	- a name used for identification
"Material"	- the material type
"Mining Step"	- the first mining step that contains the face
"Elem Type"	- element type after subdivision
"Elem SubX"	- horizontal element subdivision
"Elem SubY"	- vertical element subdivision
Nodes	- the nodes defining the geometry of the face

For more information about the properties of an element please refer to the BEAP USER MANUAL.

As described above, a face can be formed from several shapes depending on the number of nodes that define it. Figure 16 illustrates the different types of faces and the ordering of the nodes.

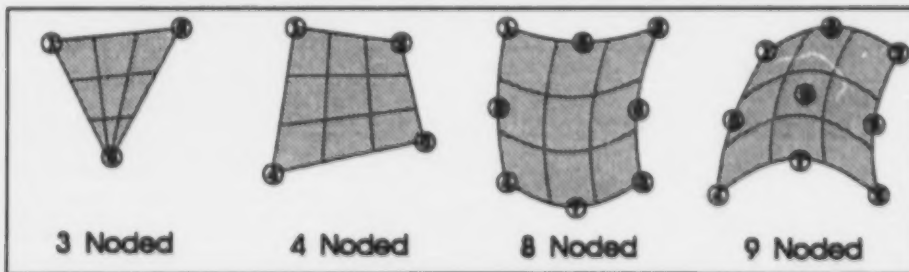


Figure 16 - The different types of faces.

8.1 Importing Stope Faces

Stope faces can be imported from text files. The imported faces are added to the existing ones. A description of the files can be found in section 9.1.3.

To import stope faces: change the menu to "Faces", "Import", enter the filename of the first data file, and then press "Import". If the filename is "geom1.dat" the file "geom2.dat" is automatically loaded. If the

filename is of the form "<name>.1" (where <name> is any valid filename) the file "<name>.2" is automatically loaded.

8.2 Editing Stopes

8.2.1 Editing Nodes

Nodes define the shape and location of the slope faces. Nodes are simply 3-dimensional points shown as circles. Nodes can be added, moved and deleted.

To begin node editing, change the menu to "*Faces*", "*Edit*", "*Nodes*". The node currently being edited is identified by a solid red circle while all other nodes are drawn as hollow black circles.

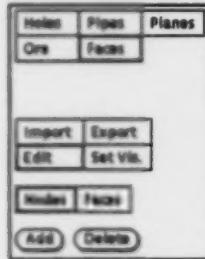


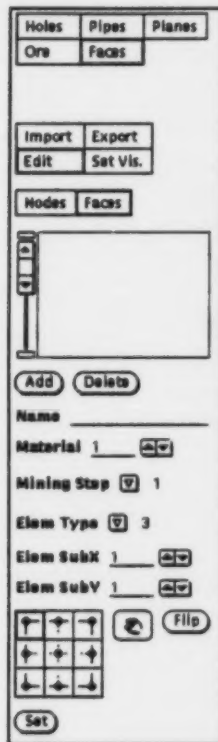
Figure 17 - "*Faces*", "*Edit*", "*Nodes*" menu

Procedures

- *to add a new node*
 - press the "*Add*" button
 - enter the location of the node
- *to select a node*
 - simply click on the node in a view if it is not already selected
- *to move a node*
 - select the node to moved
 - click on the node again
 - enter the location of the node
- *to delete a node*
 - select the node and then press the "*Delete*" button

8.2.2 Editing Faces

To begin face editing, set the menu to "*Faces*, *Edit*, *Faces*". While in this menu, the face currently being edited will be highlighted in red. The edit fields in the menu will indicate the parameters for that face. To allow for mistakes, any changes to a face are not recorded until the "*Set*" button is pressed. To ignore any changes simply select a different face in one of the views or leave the "*Faces*, *Edit*, *Faces*" menu.



There are some editing fields in the menu that require some special discussion.

A list of the faces by name is provided to allow the user to select a face by name. The list is sorted in the order that the faces were created.

A 3x3 grid of buttons or node pad is provided in the menu to symbolize the nodes defining a face. The node pad provides a means of identifying and entering the series of nodes.

Figure 18 - "Faces, Edit, Faces" menu.

Procedures

- *to add a new face*
 - press the "Add" button
 - make all necessary changes to the face
- *to select an face*
 - simply click anywhere on the face in a view if it is not already selected or click on the name of the face in the list of face names
- *to delete a face*
 - select the face
 - press the "Delete" Button
- *to change the properties of a face*
 - select the face
 - change the required properties in the menu
- *to view the nodes*
 - press the node pad button corresponding to the node in question. The node will be highlighted in the views as a solid red circle.
- *to define all nodes*
 - press the  button

- click on the first node in one of the views. The node pad will then show the next node to be entered
- click on the next node in one of the views
- continue until all nodes are entered

- *to change the nodes*
 - press the  button
 - press the node pad button corresponding to the node that is to be changed
 - click on the new node in one of the views. The node pad will change to the next button

- *to remove a node*
 - press the  button
 - press on the node pad button corresponding to the node that is to be removed
 - press on the node pad button again

- *to reverse the order of the nodes*
 - press the "Flip" button

- *to record face changes*
 - press the "Set" button or click the centre mouse button in one of the views

- *to ignore any changes*
 - press the "Faces" menu item or select a different face

8.3 Exporting Stope Faces

Stope faces can be exported before or after subdivisioning. Exporting faces before subdivisioning keeps the subdivisioning values intact so that the file can be once again imported into MD without changing the faces. Exporting faces after subdivisioning creates a proper data file for BEAP3D with the faces being irreversibly subdivided.

To export stope faces: change the menu to "Faces", "Export", enter the filename as described in section 8.1 above, set the subdivision option and then press "Export".

9. TECHNICAL DESCRIPTIONS

9.1 Data File Formats

9.1.1 Drill Hole Data

This data file provides the descriptions for any number of drill holes. Each drill hole consists of a series of points and up to 4 grades describing the segment that follows.

n	name					
x ₁	y ₁	z ₁	g ₁₁	[g ₁₂	[g ₁₃	[g ₁₄]]
x ₂	y ₂	z ₂	g ₂₁	[g ₂₂	[g ₂₃	[g ₂₄]]
.						
.						
.						
x _{n-1}	y _{n-1}	z _{n-1}	g _{n-1 1}	[g _{n-1 2}	[g _{n-1 3}	[g _{n-1 4}]]
x _n	y _n	z _n				
n	name					
.						
.						
.						

where: n number of points along the drill hole
 name text label for drill hole
 x_i y_i z_i coordinates for ith point along the drill hole
 g_{ij} jth grade for the segment between the ith and i+1th
 points along the drill hole. Note: [] denote optional.

9.1.2 Ore Body Data

This data file provides the descriptions for any number of ore body edges. Each edge consists of a series of points. If the edge is closed, the first and last points must be identical.

1	x_{11}	y_{11}	z_{11}
2	x_{12}	y_{12}	z_{12}
.			
.			
n	x_{1n}	y_{1n}	z_{1n}
1	x_{21}	y_{21}	z_{21}
2	x_{22}	y_{22}	z_{22}
.			
.			
m	x_{2m}	y_{2m}	z_{2m}
1	x_{31}	y_{31}	z_{31}
.			
.			

where: $x_{ij} y_{ij} z_{ij}$ coordinates for j^{th} point along the j^{th} ore body edge
 n, m number of points in the edge (2...128)

9.1.3 Stope Face Data

Stope data requires two data files. There are two naming conventions: geom1.dat and geom2.dat or fname.1 and fname.2 (where fname is any valid file name). For a more detailed description of the contents of these files refer to the BEAP USER MANUAL.

File 1

nn,	nf		
$x_0,$	$y_0,$	z_0	
1	x_1	y_1	z_1
2	x_2	y_2	z_2
.			
.			
nn	x_{nn}	y_{nn}	z_{nn}
1	s_1	n_{11}	$n_{12} \dots n_{1 \ s1}$
2	s_2	n_{21}	$n_{22} \dots n_{2 \ s2}$
.			
.			
nf	s_{nf}	$n_{nf \ 1}$	$n_{nf \ 2} \dots n_{nf \ s_{nf}}$

where: nn number of nodes
nf number of faces
 $x_0 y_0 z_0$ coordinates for approximate mass centre of stope data
 $x_i y_i z_i$ coordinates for i^{th} node

s_j number of sides on j^{th} face
 n_{jk} k^{th} node number for j^{th} face

File 2

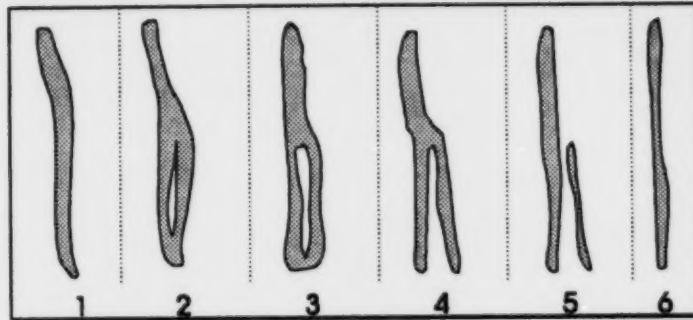
start,	end,	ex,	bCod,	colour,	srL,	srI,	libCod,	subX,	subY
.	.	.	.	.	.	.	.	.	.
0,0,0,0,0,0,0,0,0,0									

where: start first element in series
 nf last element in series
 ex excavation number
 bCod boundary condition code
 colour identification colour of the element (1-8)
 srL subregion number containing the element
 srI subregion number to which the element interfaces
 libCod library code for the element
 subX, subY subdivisioning of the element

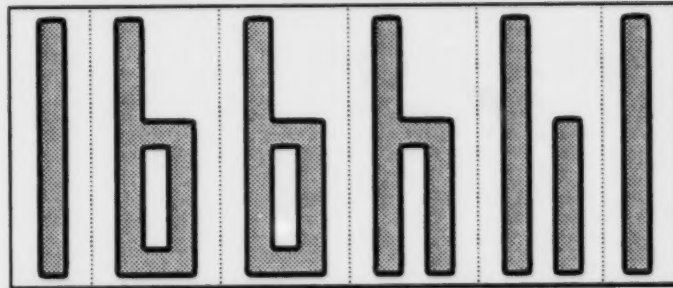
10. EXAMPLES

10.1 Ore body definition

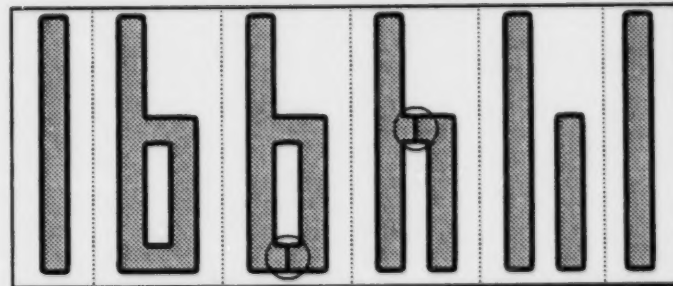
For this example it is assumed that the following ore body edges were digitized from sections. The spacing of the sections is assumed to be regular and the sections are assumed to be parallel.



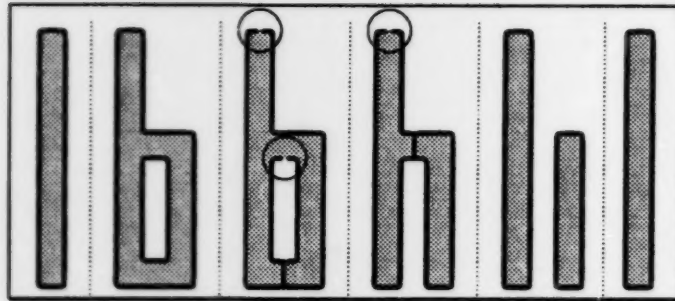
To simplify the geometry a more symbolic representation of the edges will be used.



To allow for the transition from section 3 to section 4 an extra edge must be created allowing for the topological change. Similarly section 4 must have an additional edge to allow for the changes between sections 4 and 5.

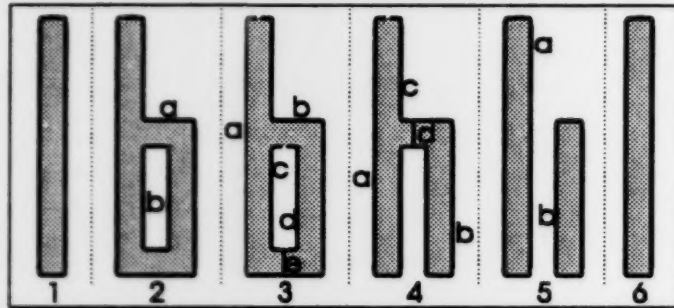


The mesh generator does not consider the order in which the edge set is created. It is therefore necessary to break the edges defining section 3 at the indicated locations to remove the confusion that will likely result. Section 4 must also be broken as indicated to accommodate for section 3.



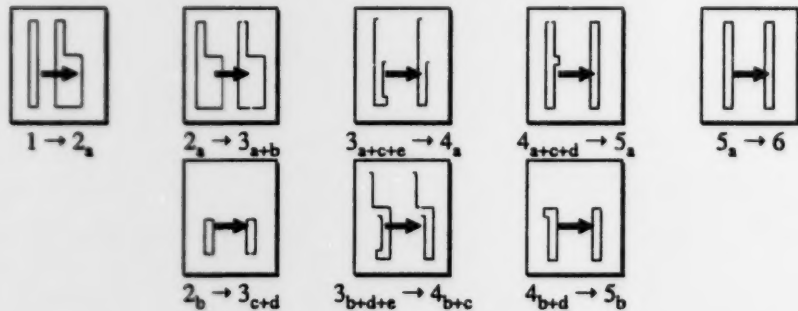
Patches

Once the edges are complete, patches can be created between the various sections



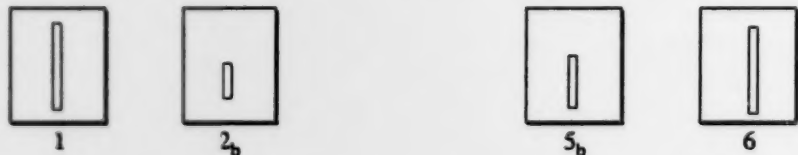
Side Patches

The side patches that must be made are as follows:



Cap Patches

The cap patches that must be made are as follows:



Note: inside

The patches shown above illustrate one possible way to define the ore body. These patches may have to be broken down into smaller patches if the mesh generator has problems creating the desired appearance. The problems that the mesh generator may have will depend on the geometry of the real model.